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Liquid Crystal Lasers: From Concepts to Realisation

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Liquid Crystal Lasers are now recognised [1] in many forms, band –edge, random, defect mode to name but a few. Lasing has been observed in Blue Phases, Chiral Nematic, Defect Doped Nematics and Chiral Smectics. Of these we have found that so called Long-Wavelength Band Edge Lasing in Chiral Nematics, sometimes called Cholesterics, give the highest slope efficiency ($\sim 70\%$), where, slope efficiency is defined as the lasing energy output/energy input/pulse [2]. We briefly describe the background to Microscopic Liquid Crystal lasers, based on dye doped Chiral Nematics, their *modus operandi* and then consider the key properties of the liquid crystal host & cavity design that lead to such high slope efficiencies, low laser thresholds ($\sim 25\text{nJ/pulse}$), narrow line widths ($<0.01\text{nm}$), laser outputs continuously tunable over a 450 to 850 nm wavelength range and quasi-continuous working (3kHz pulse rate) giving average powers of 5mW per pixel or laser spot. Laser pulse widths are typically 1-5ns.

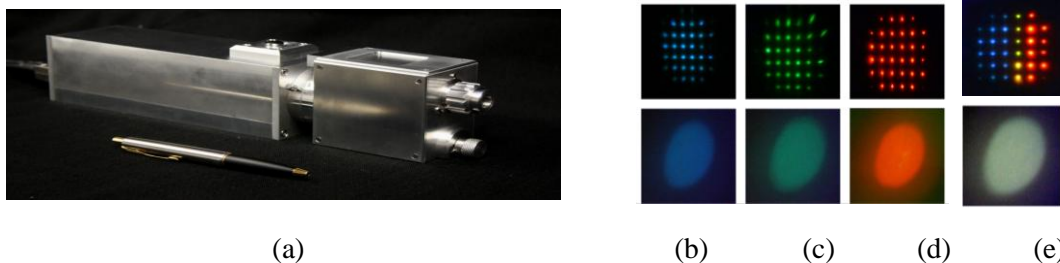


Fig 1: (a) LC laser demonstrator, (b - d) laser emission from separate 2-D laser arrays with far field images, and (e) polychromatic laser with far-field white light.

The birefringence, the elastic constants and the orientational order parameters of the liquid crystals and the fluorescent light harvesting dye (as well as the spectral absorption coefficient and peak absorption and emission wavelengths to give the maximum density of photon states at the band edge), are the key parameters that influence markedly the performance of such LC lasers. 2-D lenslet arrays of up to 100 by 100 spots have been used to give a quasi- continuous working wide colour gamut RGB laser output [3] with powers of Watts in the far field. Such outputs may be combined to give “white light” laser based outputs. We will show how the narrow band output from these microscopic cavity lasers may be continuously wavelength tuned through the application of in-plane electric fields and we will describe a multi-wavelength prototype, continuously tunable from the ultraviolet to near infrared, with an 8inch by 2inch footprint and 2inches high used for projection through computer generated holograms and medical/spectroscopic applications. We will consider new “Random Lasing” Smectic A systems, in which an electric field is used to switch the laser properties and Blue Phase lasers operable over, in principle, a 250°C temperature range. Finally we will describe new paintable/ ink-jet printed band-edge lasers that have been coated on flexible plastic and foil substrates and used for holographic projection displays. We expect applications of this new generation of highly versatile tuneable low cost lasers in portable (i.e. hand-held) fluorescence-based medical diagnostics tools, Raman & confocal fluorescence Spectroscopies.

References:

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